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(54) **END TO END EMERGENCY RESPONSE**

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**G08B 25/00** (2006.01)  
**G08B 1/08** (2006.01)  
**G08B 13/14** (2006.01)  
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340/572.1; 340/573.1

(58) **Field of Classification Search**

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See application file for complete search history.

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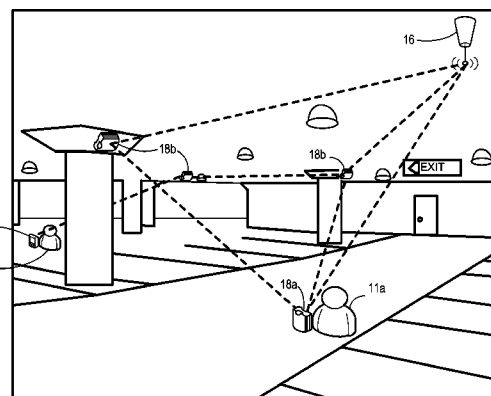
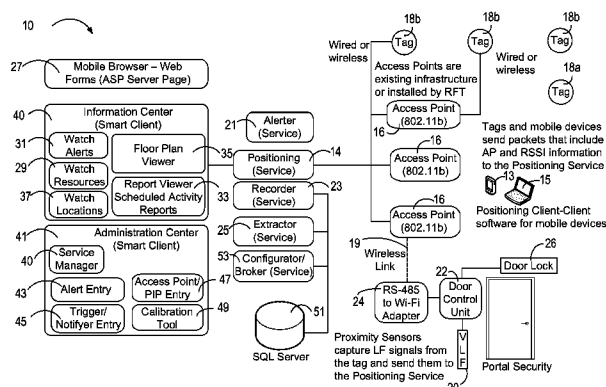
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(57) **ABSTRACT**

A system can be for use with a number of reference tags disposed at respective reference locations in a coverage area. The reference tags can be configured to form a wireless mesh network. A system can include a first tag configured to communicate with the reference tags. The first tag can operate in a sleep mode and includes a motion sensor. The first tag is woken out of the sleep mode on a first periodic basis to communicate with the reference tags. The first tag is woken out of the sleep mode at a second periodic basis in response to motion signal from the motion sensor. The second periodic basis is more frequent than the first periodic basis. The system can also include a positioning system configured to receive data related to the communication between the first tag and the reference tags. The positioning system can be configured to process the data to determine a location of the first tag.

**20 Claims, 9 Drawing Sheets**



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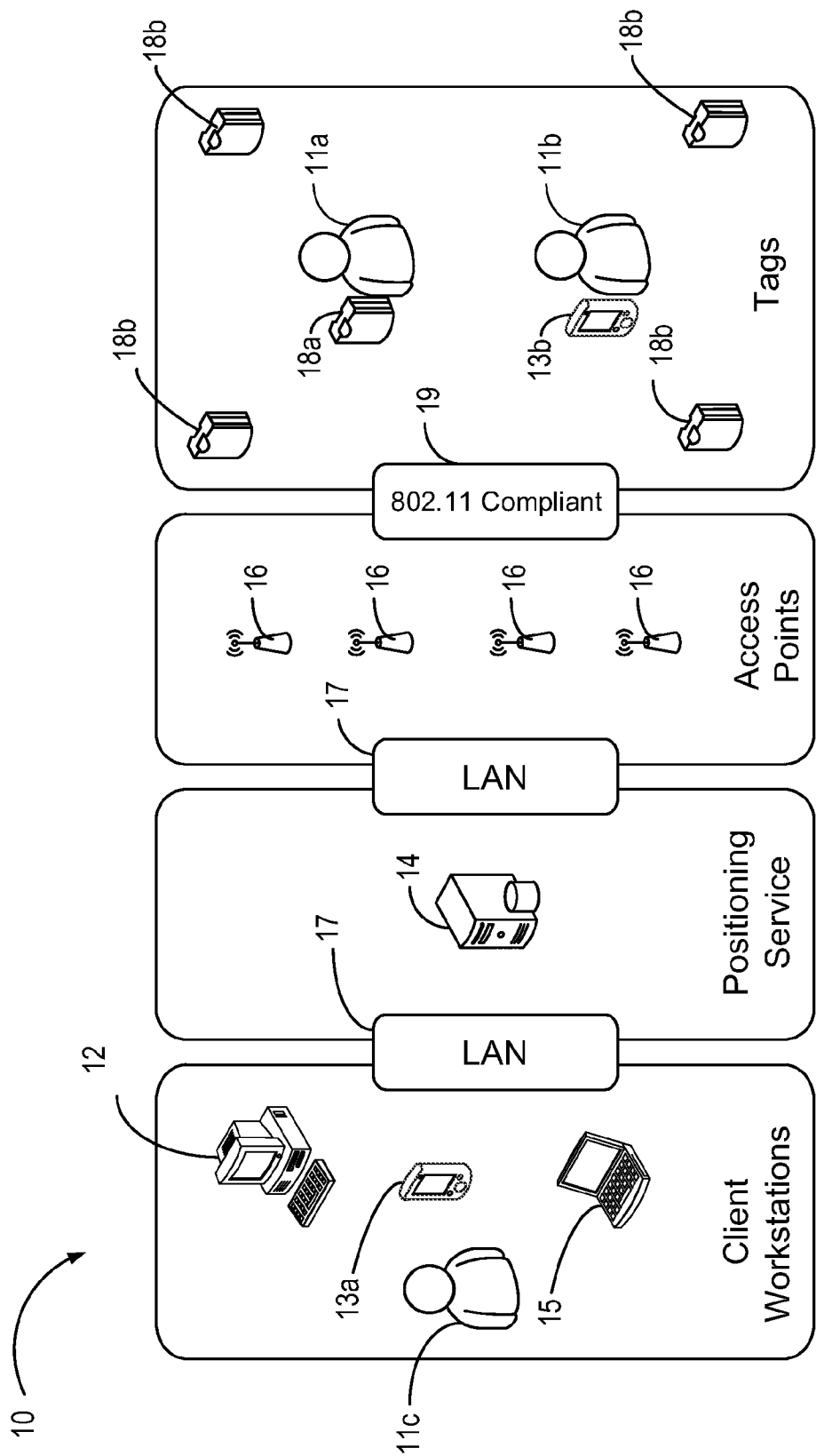


FIG. 1

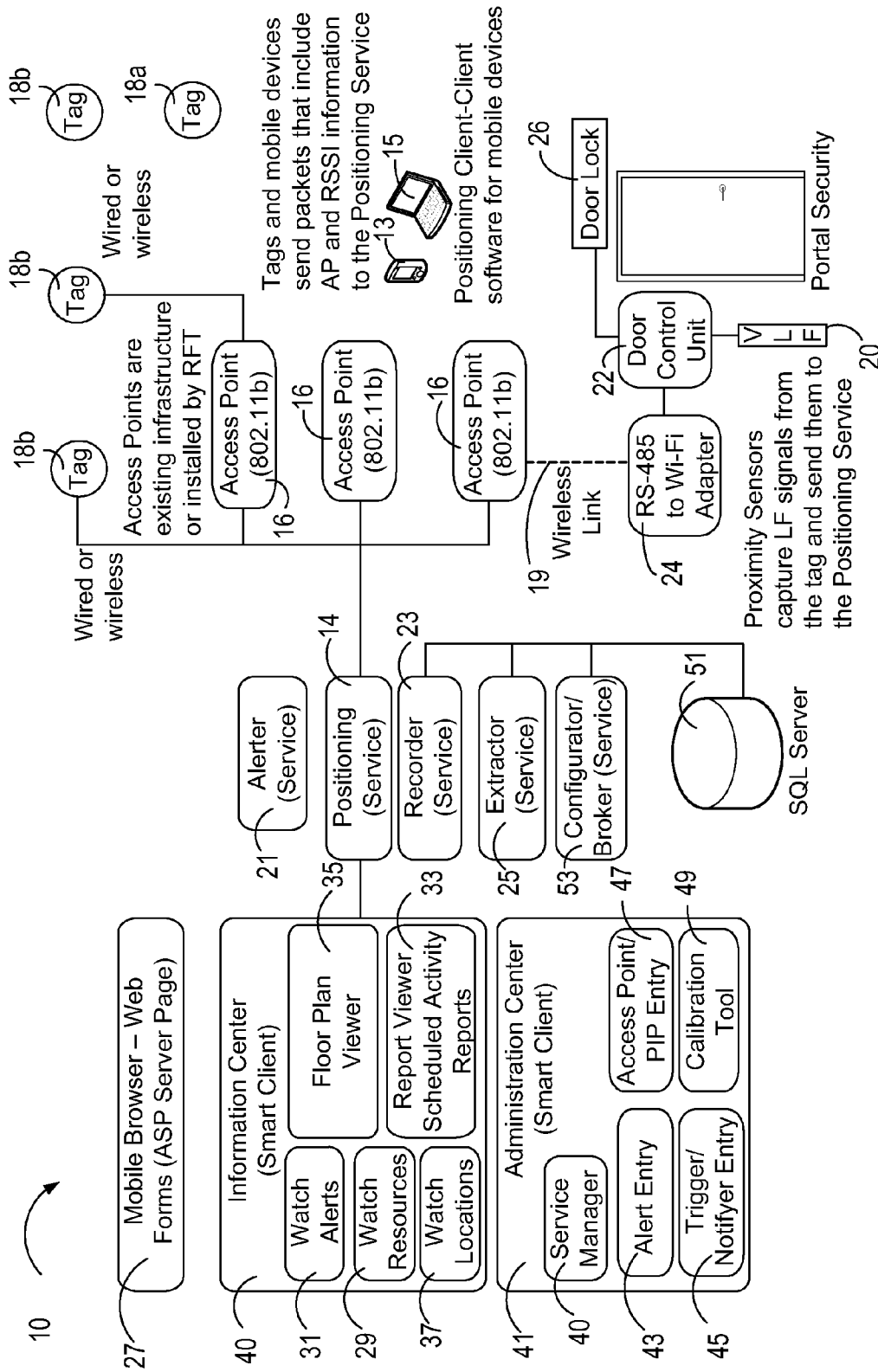


FIG. 2

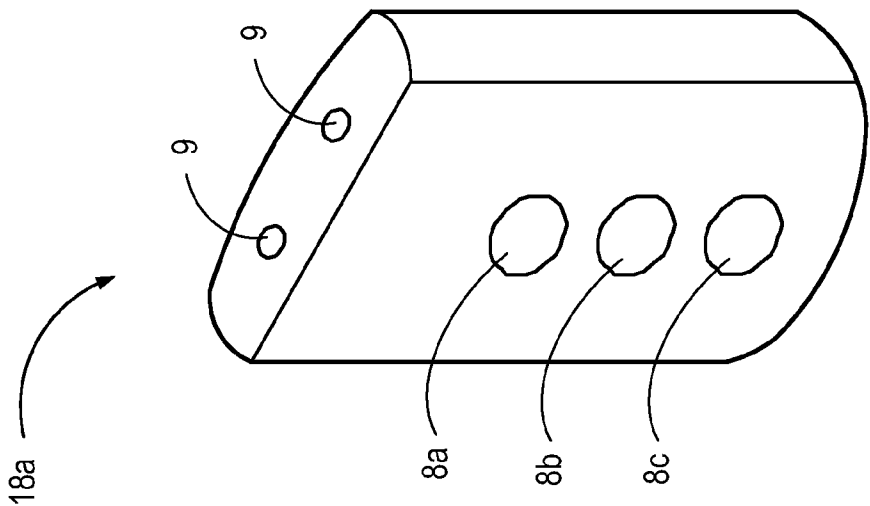


FIG. 3A

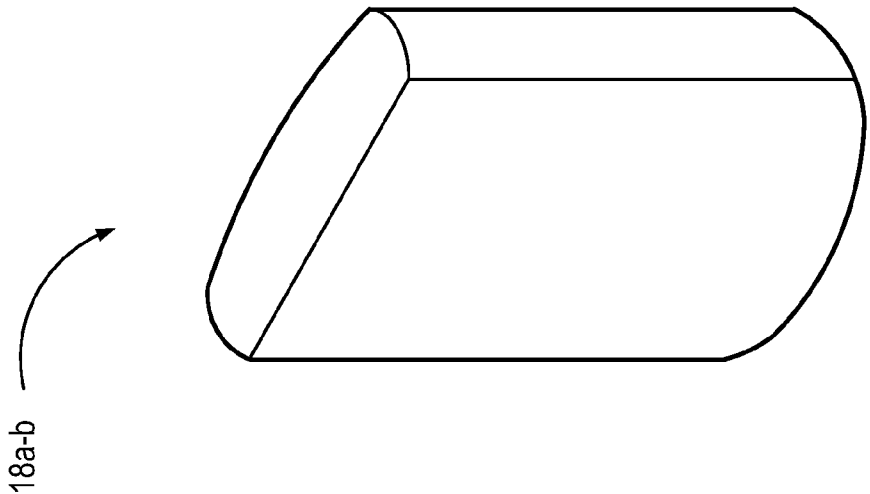


FIG. 3B

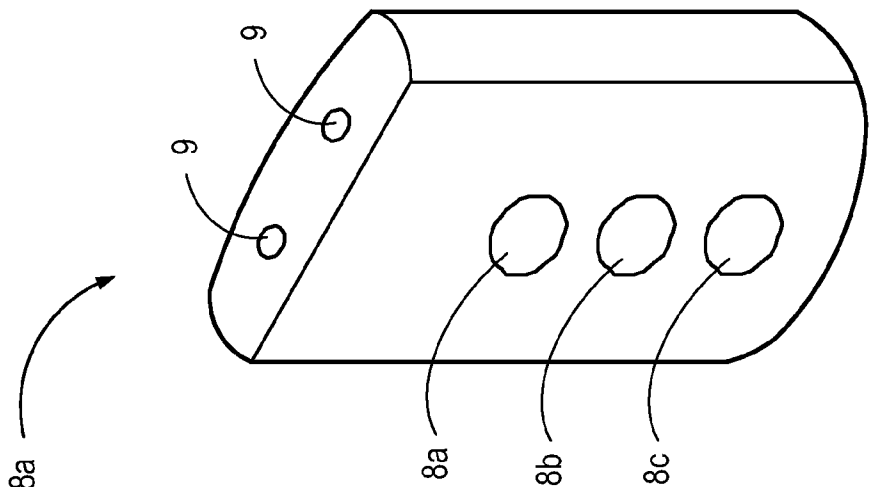


FIG. 3C

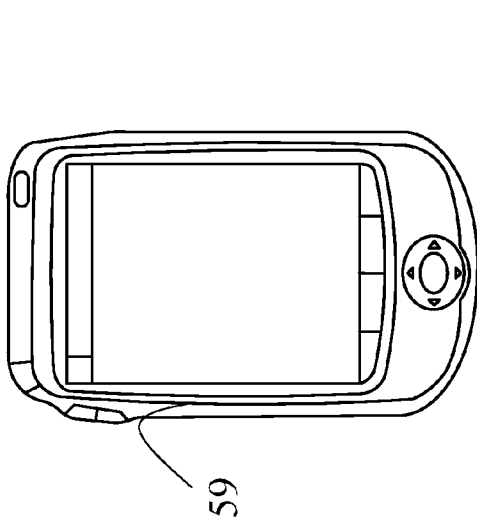


FIG. 4B

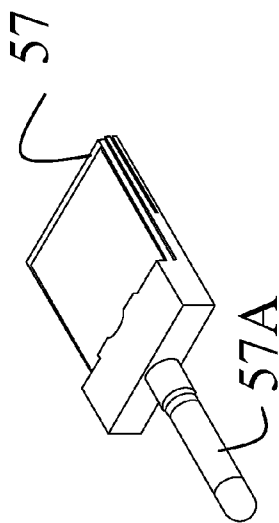


FIG. 4C

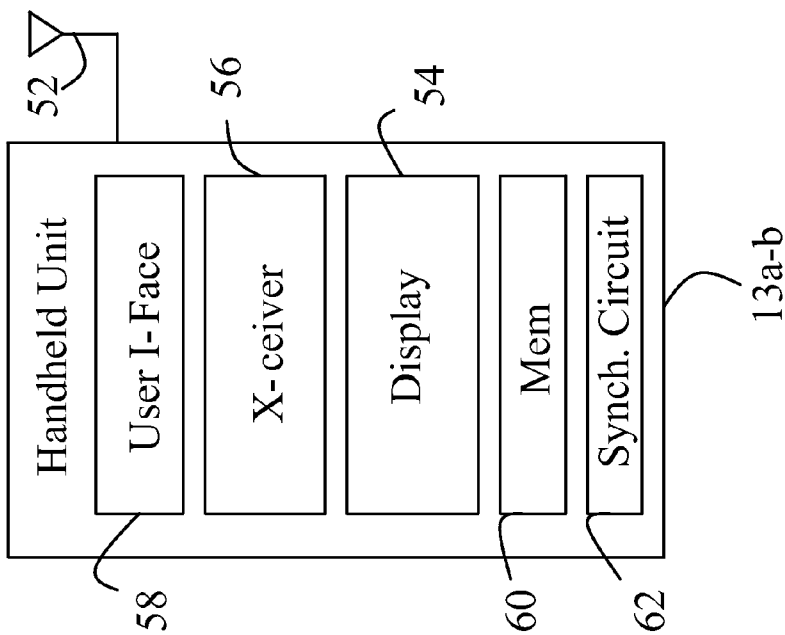


FIG. 4A

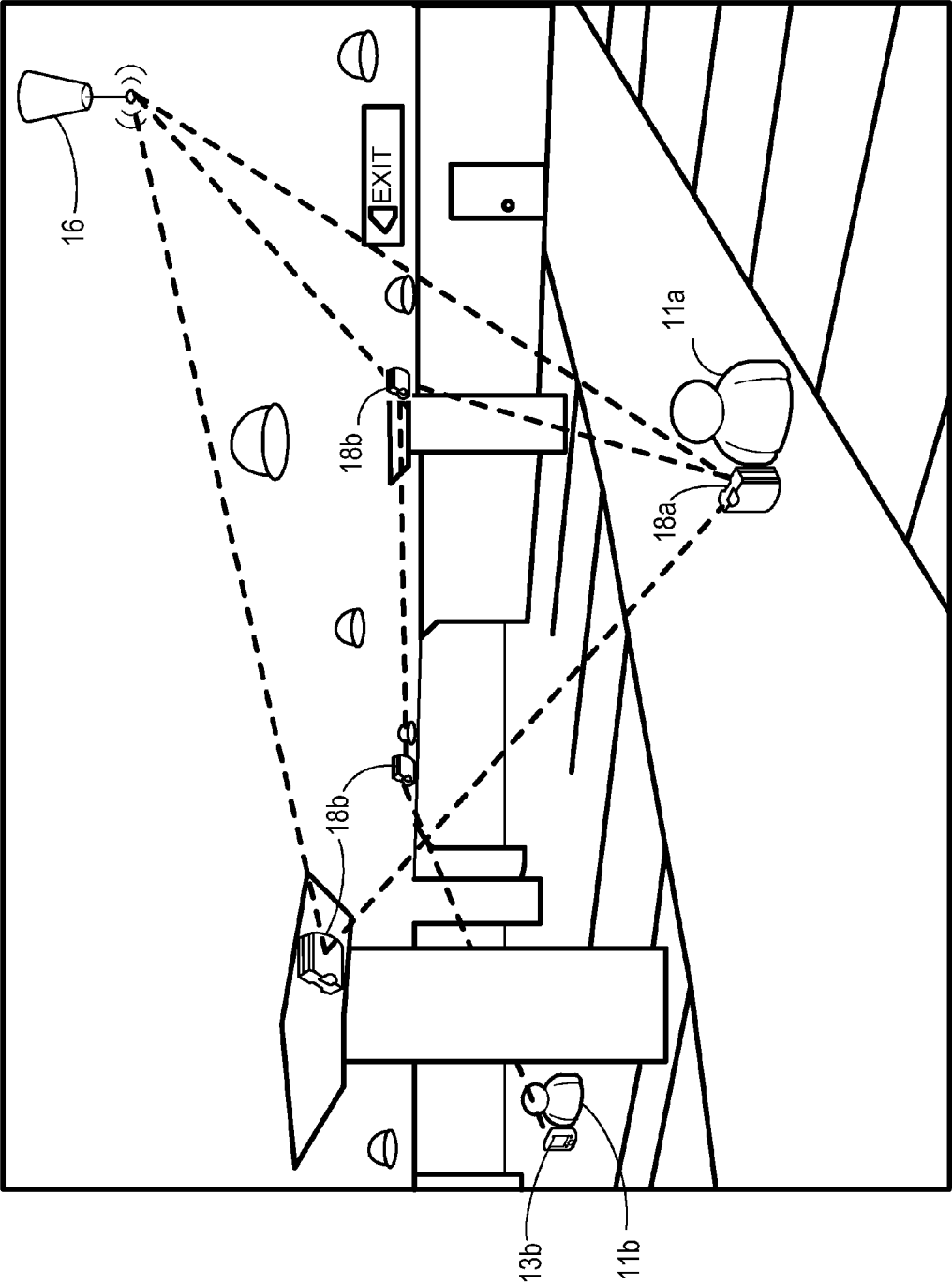


FIG. 5

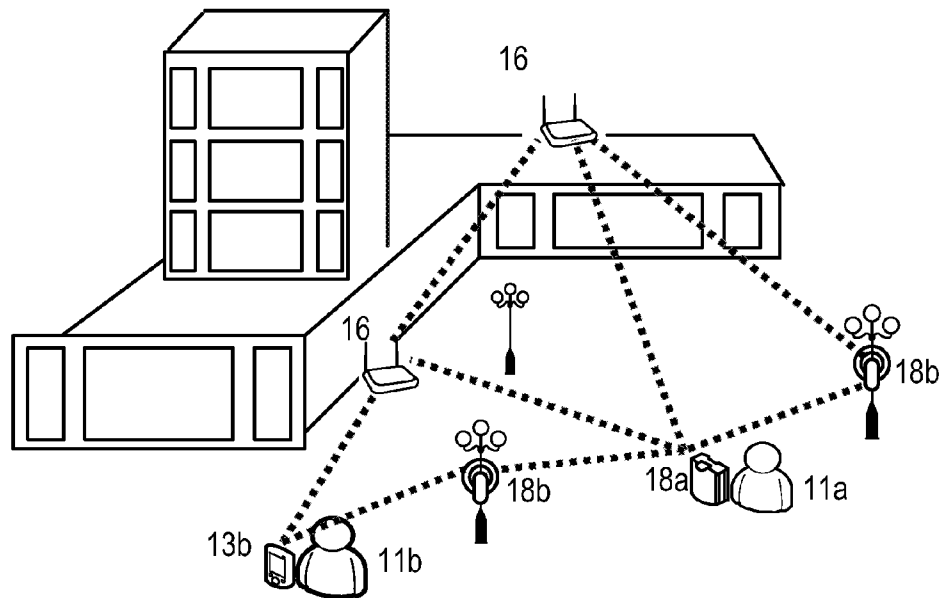


FIG. 6A

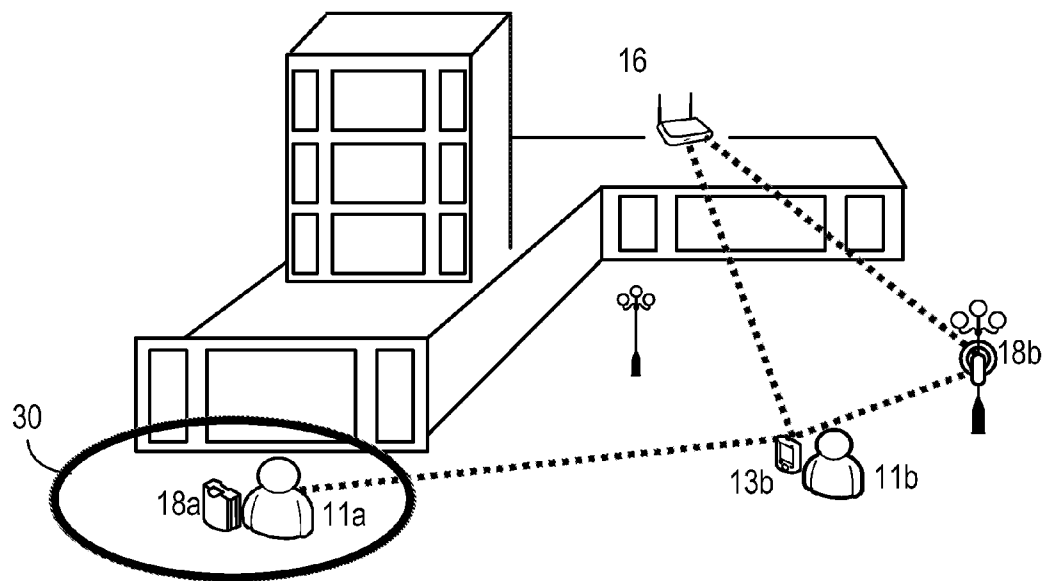


FIG. 6B



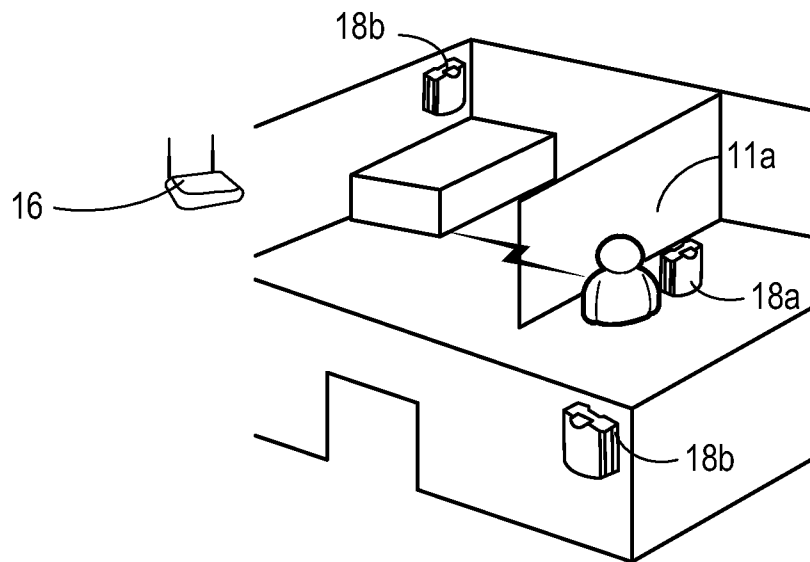


FIG. 7A

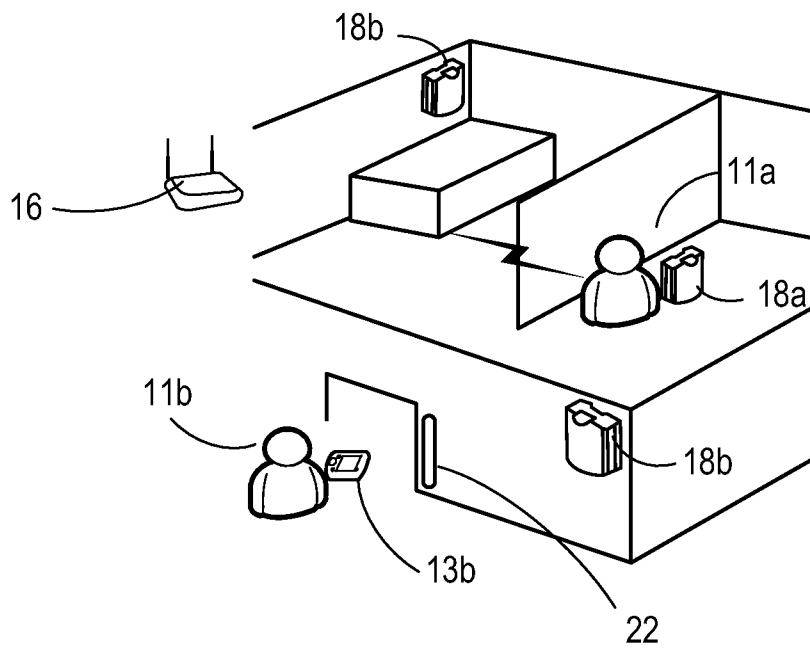


FIG. 7B

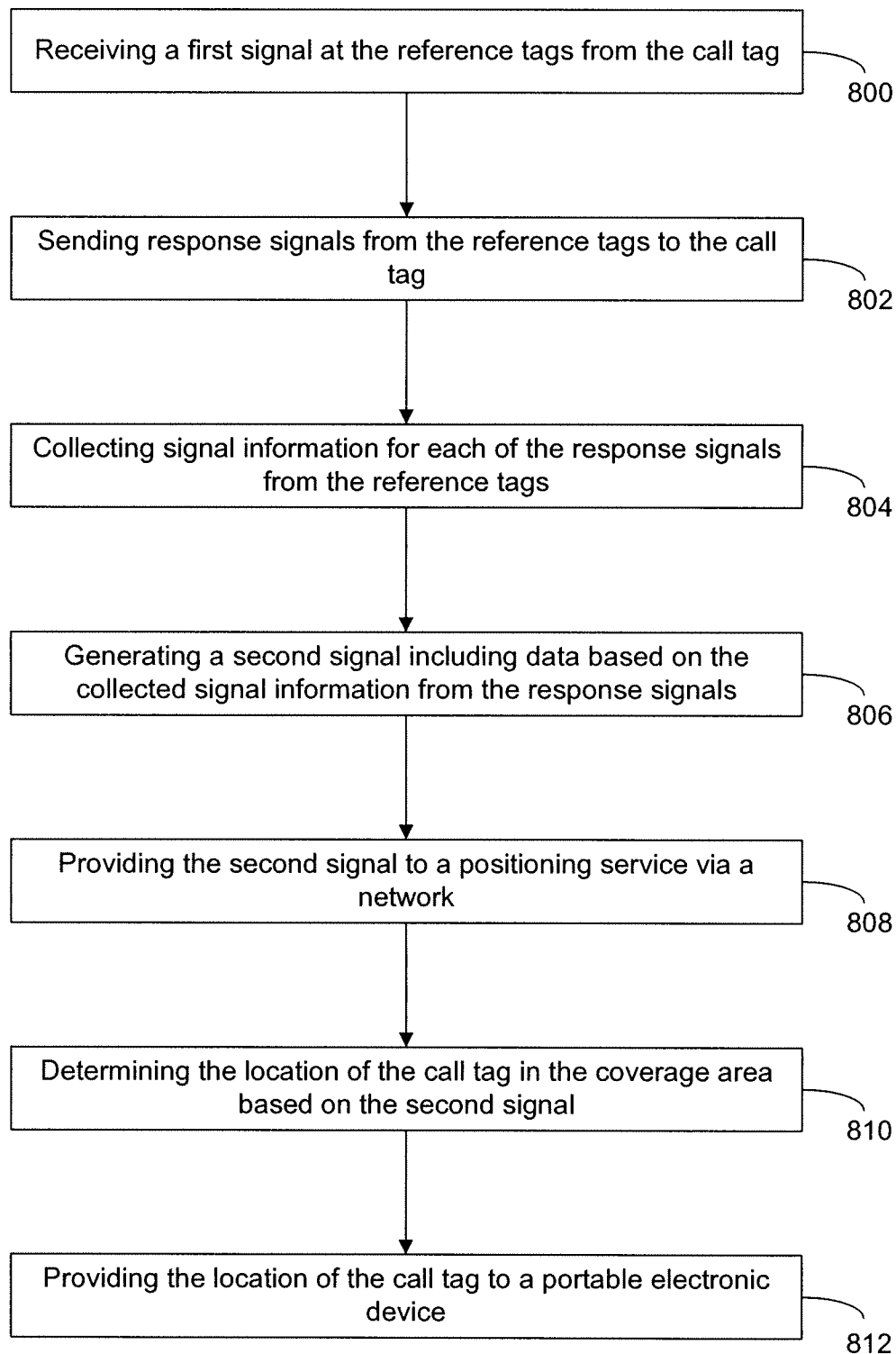


FIG. 8

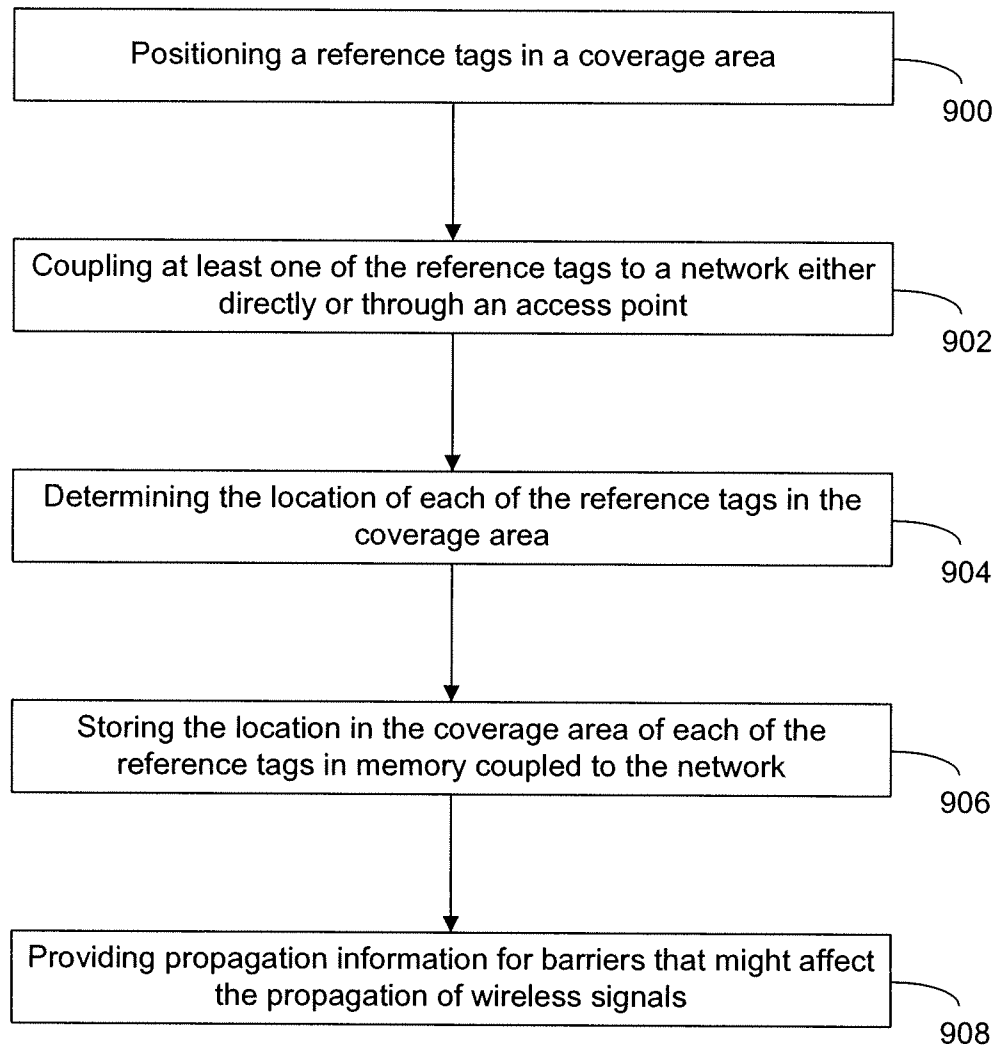


FIG. 9

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**END TO END EMERGENCY RESPONSE****CROSS-REFERENCE TO RELATED PATENT APPLICATIONS**

This application is a continuation of U.S. application Ser. No. 12/347,785, filed Dec. 31, 2008, incorporated herein by reference in its entirety, which is a continuation-in-part of U.S. application Ser. No. 12/178,480, filed Jul. 23, 2008, incorporated herein by reference in its entirety, which claims priority from U.S. Provisional Application Ser. No. 60/961,894, filed Jul. 25, 2007, incorporated herein by reference in its entirety, and which is also a continuation-in-part of U.S. application Ser. No. 12/036,136, filed Feb. 22, 2008, incorporated herein by reference in its entirety, which claims priority from U.S. Provisional Application Ser. No. 60/961,894, filed Jul. 25, 2007, incorporated herein by reference in its entirety.

**BACKGROUND**

The present application relates generally to a locator system. More particularly, the present application relates to an emergency response locator system utilizing radio frequency tags.

Locator systems can be utilized for asset and personnel tracking. Locator systems are described in U.S. Pat. No. 7,274,294, filed Jan. 26, 2005, entitled "MOBILE LOCATOR SYSTEM AND METHOD" by Heinze et al. and U.S. Pat. No. 7,365,645, filed Mar. 17, 2006, entitled "MOBILE LOCATOR SYSTEM AND METHOD WITH WANDER MANAGEMENT" by Heinze et al. both of which are assigned to the assignee of the present application and incorporated herein by reference in their entireties.

Generally, a locator system may comprise a dedicated handheld transceiver specifically designed to display data, execute software and provide RF signals that wirelessly poll the RF tags. The handheld transceiver includes a memory to store data received from the RF tags. Dedicated handheld units are expensive because they require a user interface, a power supply, a memory, a processor, and RF circuitry.

The RF tags typically include a transceiver and a memory powered by a battery. The memory of the RF tags are preprogrammed with a specific address or identification number. The RF tags may be carried by personnel, affixed to the outside of an item or integrated within the equipment that is to be tracked or located.

To locate an asset or personnel, the handheld transceiver provides an interrogation signal. All RF tags within the range of the interrogation signal respond to the interrogation signal and provide a signal containing the identification of the RF tag to the handheld transceiver.

Although conventional handheld locator systems provide an indication that the asset is within range of the interrogation signal, locator systems have not been utilized in emergency response situations to precisely locate the person in need of assistance. Thus, there is a need for an emergency response locator system configured to more precisely locate a person in need of assistance.

**SUMMARY**

One embodiment of the application relates to a system comprising a plurality of reference tags affixed to reference locations in a coverage area and configured to form a wireless mesh network. The system also includes a call tag configured to communicate with the plurality of reference tags and to

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collect data regarding the communication with the plurality of reference tags. The call tag is configured to send a first signal in response to an event. A positioning system is coupled to the wireless mesh network and configured to receive the first signal and the data collected by the call tag. The positioning system is further configured to process the data collected by the call tag to determine the call tag location with respect to the plurality of reference tags. A portable electronic device is configured to communicate with the wireless mesh network and configured to receive the call tag location from the positioning system.

A second embodiment of the application relates to a system comprising a plurality of reference tags affixed to reference locations in a coverage area and configured to form a wireless mesh network. The system further includes a call tag configured to communicate with the plurality of reference tags and to collect data regarding the communication with the plurality of reference tags. The call tag is further configured to send a first signal in response to an event.

A third embodiment of the application relates to a method for providing a wireless emergency response network. The method comprises positioning a plurality of reference tags in a coverage area. The reference tags are configured to communicate with one another and a plurality of call tags that enter the coverage area. The method also includes coupling a first reference tag of the plurality of reference tags to a local area network. The first reference tags is configured to communicate data from the plurality of reference tags and the plurality of call tags that enter the coverage area to the local area network. The method further includes determining the location of each of the plurality of reference tags in the coverage area and storing the location of each of the plurality of reference tags in a memory coupled to the local area network.

A fourth embodiment of the application relates to a method for determining the location of a call tag in a wireless emergency response network. The method comprises receiving a first signal at a plurality of reference tags from a call tag. The plurality of reference are disposed in coverage area. The method also includes sending response signals from the plurality of reference tags to the call tag and providing a second signal from the call tag to a positioning service via a network. The second signal includes data based on the response signals from the plurality of reference tags. The positioning service and the plurality of reference tags are coupled to the network and the positioning service is configured to determine the location of the call tag in the coverage area based on the second signal.

A fifth embodiment of the application relates to a system can be for use with a number of reference tags disposed at respective reference locations in a coverage area and configured to form a wireless mesh network. The system can include a first tag configured to communicate with the reference tags. The first tag can operate in a sleep mode and includes a motion sensor. The first tag is woken out of the sleep mode on a first periodic basis to communicate with the reference tags. The first tag is woken out of the sleep mode at a second periodic basis in response to motion signal from the motion sensor. The second periodic basis is more frequent than the first periodic basis. The system can also include a positioning system configured to receive data related to the communication between the first tag and the reference tags. The positioning system can be configured to process the data to determine a location of the first tag.

A sixth embodiment of the application relates to a tag unit for use with reference tags disposed at reference locations in a coverage area and configured to form a wireless mesh network. The tag unit includes a processor configured to

communicate with the reference tags and to collect data regarding communication with the reference tags, and a motion sensor. The tag unit operates in a sleep mode. The tag unit is woken out of the sleep mode on a first periodic basis to communicate with the reference tags and is woken out of the sleep mode at a second periodic basis and response to a motion signal from the motion sensor. The second periodic basis is more frequent than the first periodic basis.

A seventh embodiment of the application relates to a method of determining a location of a tag unit in a wireless emergency response network. The method includes waking the tag unit from a sleep mode on a first periodic basis to communicate with reference tags. The method also includes waking the tag unit from the sleep mode at a second periodic basis in response to a motion signal from a motion sensor. The second periodic basis is more frequent than the first periodic basis. The reference tags can be disposed in a coverage area. The method also includes determining the location of the tag unit in the coverage area based on data associated with communication between the tag unit and the reference tags.

An eight embodiment of the application relates to a system for use with a number of reference tags disposed at respective reference locations in a coverage area and configured to form a wireless mesh network. A system can include a first tag configured to communicate with the reference tags. The first tag can operate in a sleep mode and includes a motion sensor. The first tag is woken out of the sleep mode on a first periodic basis to communicate with the reference tags. The first tag is woken out of the sleep mode at a second periodic basis in response to motion signal from the motion sensor. The second periodic basis is more frequent than the first periodic basis. The system can also include a positioning system configured to receive data related to the communication between the first tag and the reference tags. The positioning system can be configured to process the data to determine a location of the first tag.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general block diagram of an emergency response locator system according to an exemplary embodiment.

FIG. 2 is a block diagram of an overview of an emergency response locator system according to another exemplary embodiment.

FIG. 3A is a block diagram of a tag unit for use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 3B is a perspective view drawing of a tag unit for use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 3C is a perspective view drawing of a call tag for use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 4A is a block diagram of a mobile device for use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 4B is a top view general drawing of a mobile device (e.g., handheld computer) for use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 4C is a perspective view schematic drawing of an RF module to use in the system illustrated in FIGS. 1 and 2 in accordance with another exemplary embodiment.

FIG. 5 is a perspective view of a parking garage with a wireless mesh network configuration for enabling an emer-

gency responder to locate a distressed person in accordance with another exemplary embodiment.

FIG. 6A illustrates a wireless mesh network configuration for locating a distressed person, where the distressed person is located within the coverage area, in accordance with another exemplary embodiment.

FIG. 6B illustrates a wireless mesh network configuration for locating a distressed person, where the distressed person is located outside the coverage area, in accordance with another exemplary embodiment.

FIG. 7A is a perspective view of a care facility environment in which a wireless mesh network configuration is employed for locating a distressed person in accordance with another exemplary embodiment.

FIG. 7B is a perspective view of a care facility environment in which an emergency responder is attempting to locate a distressed person in response to a transmitted alert signal in accordance with another exemplary embodiment.

FIG. 8 is a flow diagram showing the steps for locating a distress person in accordance with another exemplary embodiment.

FIG. 9 is a flow diagram showing the steps for configuring a wireless mesh emergency response network in accordance with another exemplary embodiment.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an end-to-end emergency response locator system 10 is illustrated according to an exemplary embodiment. Emergency response locator system 10 can be used to provide assistance to distressed persons 11a in the event of an emergency by tracking and locating call tag 18a carried by distressed person 11a. Emergency response locator system 10 may be configured to use IEEE 802.11 wireless networking standard. Employing this standard, advantageously allows emergency response locator system 10 to utilize an existing wireless infrastructure 19, however, other wireless standards could be employed without departing from the scope of the application.

Generally, emergency response locator system 10 includes a plurality of reference tags 18b, one or more call tags, a positioning system (e.g., positioning service 14) and one or more portable electronic devices. The plurality of reference tags 18b are affixed to reference locations in a coverage area and configured to communicate with one another to form a wireless mesh network. The one or more call tags 18a are configured to communicate with the plurality of reference tags 18b and to collect data regarding the communication with the plurality of reference tags 18b. The call tag is further configured to send a signal to a positioning service in response to an event. The positioning service is coupled to the wireless mesh network and configured to receive the signal from call tag 18a. The signal may be transmitted over a network, such as a LAN, to which the positioning system and the wireless mesh network are both coupled. The signal from the call tag may contain the data collected by call tag 18a or the data collected may be sent in a separate signal. The positioning system is configured to process the data collected by call tag 18a to determine the location of call tag 18a in the coverage area with respect to the plurality of reference tags.

Emergency response locator system 10 may also include one or more standard networking devices, such as access point 16. Access points 16 may be configured broadcast wireless signals using an 802.11 wireless standard 19, that can be received by tag units 18a-b and portable electronic devices, such as mobile devices 13a-b (e.g., mobile phone, PDA).

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Access point **16** may serve to couple the wireless mesh network to a network, such as local area network (LAN) **17**, or any other type of network, for communication with the positioning system (e.g., positioning service **14**). Furthermore, access point may serve to couple the wireless mesh network to the Internet or other types of wide area networks for communicating with a remote positioning system. Emergency response locator system **10** may also be configured to use access point **16** like a reference tag. For example, call tag **18a** may be configured to communicate with access point **16** and to collect data regarding the communication with access point **16** and provide the data to the positioning system to assist in locating the call tag **18a** in the coverage area. In this example, the location of access point **16**, with respect to the coverage area, including the other reference tags **18b**, is known by the positioning system.

Call tag unit **18a** may be configured to measure and/or collect relative signal strengths of signals from reference tags **18b** and access points **16**. These signals may be transmitted from reference tags **18b** and access points **16** in response to a broadcasted probe signals from call tag **18a**. Alternatively, reference tags **18a** and/or access point **16** may be configured to periodically transmit a signal. The period between transmissions may be dependent on the call tag **18a**. For example, if an event occurs (e.g., an emergency situation indicated by call tag **18a**), then the reference tags **18b** may be configured to transmit at a faster rate in order to provide more accurate location information. This may be especially important if the distressed person **11a** carrying the call tag **18a** is moving (e.g., running). Call tag collects the data from the signals transmitted from reference tags **18b** and access points **16**, such as signal strength information, and communicates the collected signal strengths to a processing system, such as a server hosting positioning service **14** through local area network (LAN) **17**. Position service **14** may be located on site or may be located remotely with respect to the coverage area. Positioning service **14** may be a PC, laptop or server, that includes one or more software suites and serves as a positioning/location engine for tag units **18a-b**, mobile devices **13b** and transmitting points.

Positioning service **14** acts as a location engine and determines the location of tag units **18a-b** and mobile devices **13b** based on calibration data collected during initial installation (e.g., location of reference tags **18b** on coverage area floor plan or map), historical movements of call tag **18a**, and statistical analysis. The location of call tag **18a** of distressed person **11a** is published to end user applications on workstation(s) **12**, laptop(s) **15** and/or mobile device(s) **13a**. The location of call tag **18a** of distressed person **11a** is also published to emergency responder **11b** via mobile device **13b**. The location of call tag **18a** of distressed person **11a** is also preserved in a database for future reporting and analysis. Users **11b-c** can view the location data on end-user devices, such as workstation **12**, mobile devices **13a-b**, and laptops **15**. In an alternative embodiment, tag unit **18a-b** may be configured to perform the analysis of the positioning service **14** as described below and act as a self locating location engine. The location, as determined by tag unit **18a-b**, is delivered to an emergency responder **11b** via mobile device **13b** and to a database for reporting and analysis and published to end user applications on workstation(s) **12**, laptop(s) **15** and/or mobile device(s) **13a**.

In an exemplary embodiment, as illustrated in FIG. 1 emergency response locator system **10** comprises positioning service **14**, which receives data associated with signal strengths between wireless access points **16**, reference tags **18b** and call tag **18a**. Positioning service **14** analyzes the data associated

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with a number of transmitting access points **16** and reference tags **18b** and determines the locations of call tag **18a**. Positioning service **14** determines the location of call tag **18a** based on the following: calibration data collected during initial installation; historical movements of call tag **18a**; and statistical analysis, or any combination thereof. Furthermore, positioning service **14** does not necessarily need to use calibration data collected during installation for calculating locations, instead, it can make use of the dynamic sample points from each reference point (e.g., transmitting points and tag units) to perform location calculations.

In an exemplary embodiment, reference tags **18b** may be configured in various arrangements to form wireless mesh networks that communicate with a processing station, such as positioning service **14**, via a network connection for determining the location of anyone of the tags. Call tag **18a** operates by collecting information about its surroundings and conveys this information to another device capable of determining the location of call tag **18a** based on the collected information. For example, call tag **18a** sends probe request messages to wireless access point **16** and reference tag **18b**. Reference tags **18b** and AP **16** respond with probe response messages from which call tag **18a** determines the received signal strength indication (RSSI) of each response signal. Call tag **18a** collects the RSSI information and communicates the information to either AP **16** or reference tag **18b**. The information is communicated to a processing station, such as positioning service **14**, that is capable of determining the location of call tag **18a** from the collected data. In addition, reference tag **18b** can send a special message to tag units **18a-b** at a pre-configured time interval. Reference tags **18b** synchronize with each other in order to send their messages at approximately the same time. Call tag **18a** wakes to listen for messages from all reference tags **18b**. Under this scenario, call tag **18a** does not need to send a probe request message to reference tag **18b**. However, a probe request message may be needed when communicating with AP **16**.

In addition to, or in place of, RSSI information, call tag **18a** may be configured to collect, use and send time of flight (TOF) information to facilitate location of call tag **18a**. In order to eliminate reflections and other multipath issues, reference tags **18b** and call tag **18a** can determine a rudimentary TOF for each message sent. The message with the lowest TOF is likely the most direct path between reference tag **18b** and call tag **18a**. To calculate the TOF, reference tag **18b** timestamps its message with an incremented value. Call tag **18a** timestamps the message with its own incremented value when the message is received. Call tag **18a**, or positioning service **14**, looks at the difference between each of the time stamps of the messages received from reference tag **18b** and determines which spent the least amount of time traveling to call tag **18a**. RSSI information may be used in conjunction with TOF information to determine the location of call tag **18a** in the coverage area. The location of mobile device **13a-b** may be determined in the same fashion as call tag **18a**, when the emergency responder **11b** is moving through the coverage area to locate call tag **18a** carried by distressed person **11a**.

Call tag **18a** and reference tag **18b** ideally use the same circuit board and firmware to create a tag that can be tracked, serve as a fixed reference and act as a gateway/interface to a network, such as LAN **17** or a WLAN. Reference tags **18b** are configured to communicate with one another to form a wireless mesh network. Reference tag **18b** is configured to act as a signal source, call tag **18a** collects the signals from reference tag **18b** and the collected signals are sent, via the wire-

less network to a positioning service **14** to analyze the signals from reference tags **18b** to determine the position of call tag **18a**.

Reference tag **18b** may be configured with the additional feature of providing a transport mechanism for delivering the collected packets of information to another medium, such as Ethernet. Reference tags **18b** can communicate with one another to form a wireless mesh network. Call tag **18a** collects and sends packets of information to reference tag **18b**, which repeats the information packets to another reference tag **18b** until it is finally delivered to another support media. Reference tags **18b** can be used in lieu of a wireless communications network. If no network is installed, the reference tags **18b** can be used to send information packets from call tag **18a** to positioning service **14**. This deployment model allows locating call tags **18a** carried by distressed persons **11a** in areas that do not have a wireless communications infrastructure.

Furthermore, many existing 802.11 networks **19** may not have adequate AP **16** locations or coverage to obtain the desired location accuracy. Reference tags **18b** are used to improve positioning performance by increasing coverage density and to extend the communication coverage tag unit **18** where existing wireless coverage is intermittent, inadequate, or non-existent. Reference tag **18b** can be configured to broadcast 802.11 compliant beacons to be used by tag units **18a-b** to improve performance by providing additional RSSI measurements. Alternatively, reference tag **18b** can also be configured to transmit other types of beacons. In addition, reference tag **18b** can send a special message to tag units **18a-b** at a pre-configured time interval. Reference tags **18b** synchronize with each other in order to send their messages at approximately the same time. Call tag **18a** wakes to listen for messages from all reference tags **18b**. Under this scenario, call tag **18a** does not need to send a probe request message to reference tag **18b**. However, a probe request message may be needed when communicating with AP **16**.

Reference tag **18b** can also connect as a client to an existing 802.11 wireless network to provide a wireless backhaul to an existing 802.11 network when a wired Ethernet connection is not needed. Reference tag **18b** is not a fully functional 802.11 access point **16** in that it does not allow other 802.11 devices to associate. Consequently, reference tag **18b** does not relay any data or communications other than tag units **18a-b** information. Reference tag **18b** monitors for tag units **18a-b** association requests when not transmitting to look for tag units **18a-b** position updates. Reference tag **18b** sends out an association response, which notifies tag units **18a-b** of the association ID and returns back to receive mode to collect the new tag units **18a-b** position update.

In an exemplary embodiment, implementing Circular Polarized (CP) antennas in the reference tag **18b** provides significant improvements in RSSI stability in harsh environments. RSSI values can change significantly due to multipath, orientation, polarization, fading, and other environmental factors. Signals from linear polarized antennas can vary significantly due to the factors listed above.

In an exemplary embodiment, reference tag **18b** determines delivery location of the packet to positioning service **14** by performing an address resolution protocol (ARP) frame with the server's destination IP address and a broadcast media access control (MAC) address. A switch forwards this broadcast to all ports, including one attached to a router. A router, recognizing that it can reach the server's network, will send an ARP response frame with its own MAC address as a destination MAC address that reference tag **18b** can use. Association with reference tag **18b** is not necessary because

the organizational unique identifier (OUI) at the header of the MAC address distinguishes it from the AP **16**.

Various configurations are possible, some of which do not require AP **16**. Reference tag **18b** may use any type of network protocol or network technology, wired or wireless, to communicate with positioning service **14**. Reference tag **18b** may be configured to communicate using generic packet radio service (GPRS), worldwide interoperability for microwave access (WiMAX) or any other wide area network (WAN). Reference tag **18b** may also be configured to communicate with the processing station using a radio access network (RAN).

In an exemplary embodiment, as illustrated in FIG. 2, positioning service **14** contains algorithms that determine the position of tag units **18a-b**. Positioning service **14** receives messages from tag units **18a-b** containing the RSSI values of the AP **16** in an area. Higher RSSI values correspond to stronger signals. Statistical and heuristic algorithms are applied to data and a position of tag units **18a-b** is determined and published to user **11**. Algorithm concepts that are included in an analysis can be the following or any combination thereof: histograms; static analysis; vector analysis; and geometric center analysis. Alternatively, tag units **18a-b** is configured to apply algorithms to determine its own position (e.g., self locate). In one embodiment, tag units **18a-b** transmits its location, which is eventually delivered to one or more of: positioning service **14**, alerter service **21**, recorder service **23**, extractor service **25**, configurator service **53** and SQL server **51**. Once the one or more services are performed, the location of tag units **18a-b** is delivered to information center **40**. Alternatively, the location of tag unit **18** may bypass the various services and be delivered directly to information center **40**.

In an exemplary embodiment, alerter service **21** can receive location messages from positioning service **14** and analyze them against alert rules. The rules can be defined, stating when an alert should occur, based on tag units **18a-b** and location combinations. Rules can be created using administrator center **41**.

In an exemplary embodiment, recorder service **23** can subscribe to alerter service **21** and positioning service **14**. Recorder service **23** can save changes in data received to an SQL server **51**. Data can only be recorded when changes occur.

In an exemplary embodiment, configurator service **53** can provide services, hardware, and applications with necessary configuration information stored in a central database. Configurator service **53** can create initial communication settings to allow services and clients to communicate. Configurator service **53** can also allow scalability for emergency response locator system **10** by brokering information requests. Configurator service **53** can also provide interfaces for connecting to a database and retrieving information.

In an exemplary embodiment, extractor service **25** can be queried to retrieve data recorded by recorder service **23**. Data can be used by information center **40** and PC/Mobile Web-Forms **27** to provide tracking functions and generate custom reports.

In an exemplary embodiment, information center **40** is a user interface for emergency response locator system **10**. Information center **40** can watch resources **29**, watch alerts **31**, view reports, **33**, create utilization charts, view floor plans, **35**, and monitor real-time data pertaining locations **37**.

In an exemplary embodiment, administrator center **41**, can be a primary user interface for configuring data into emergency response locator system **10**. Administrator center **41** consists of several modules that allow users tag unit entry **39**,

alert entry 43, trigger entry 45, resource entry, location entry, access point entry 47, etc. Administrator center can also be a primary tool used for calibration 49.

Information center 40 and positioning service 14 may be incorporated into one station, such as a PC or server, or a configuration of multiple PCs or servers. The station incorporating information center 40 and positioning service 14 may be remotely located with respect to the coverage area or may be on site. Information center 40 and positioning service 14 may be separate stations and either one may be remotely located with respect to the coverage area or located on site. The other services (e.g., alerter service 21, recorder service 23, extractor service 25, and configurator service 53) and SQL server 51 may be incorporated into a single station with the information center 40 or may form one or more stations at one or more locations in various configurations.

With reference to FIG. 3A-C, tag units 18a-b can be SEEKER™ tags manufactured by RF Technologies, Inc. that operate in accordance with at least one of the operations described below.

Each of tag units 18a-b is preferably a complete, self-powered electronic assembly including an RF printed circuit board, transceiver chipset, microstrip antenna for transmit and receive, and lithium coin cell battery, sealed in a plastic housing. An antenna 33 can be internal or external to the housing. Tag units 18a-b can be implemented in a variety of forms. Units 18a-b can be transponder-based tags.

Memory 28 can be any form of data storage including an EEPROM. Memory 28 can be programmed at manufacture or installation. Alternatively, memory 28 can be programmed by providing data from mobile device 13b to tag units 18a-b.

Tag units 18a-b preferably include low battery detection functionality. When one of tag units 18a-b is polled, it responds with its unique ID and a status byte indicating its battery condition. If one of units 18a-b is instructed to beep during the poll, it will may be configured to make an audible sound allowing users to gain a rough indication of where the tag is located. Tag units 18a-b may be configured with an on-board motion detector and low power management system to extend or maximize battery life. Should tag units 18a-b become stationary, the battery powers down, hence extending battery life. Tag units 18a-b can transmit low-battery alerts when replacement is eminent.

Additionally, reference tags 18b can also synchronize with each other and call tag 18a to conserve battery life. In one embodiment, the first reference tag to be activated may send a pulse signal on a periodic interval. Other reference tags 18b that become active will detect the pulse and begin sending their signals just slightly offset from the pulse. When call tag 18a wakes up, it waits for a signal and then stays awake just long enough to receive all the signals from the reference tags. Call tag 18a may be configured to then awake at the same periodic interval as the reference tags 18b, thereby maximizing its sleeping time and conserving battery life. In one embodiment, call tag transmits a signal and then stays awake just long enough to receive all the signals from the reference tags 18b.

In an exemplary embodiment, tag units 18a-b are software configurable so that any single tag unit may be configured or reconfigured to act as either a call tag, an asset tag or a reference tag. Software configurable tag units 18a-b provide maximum flexibility for adapting to new coverage areas and new coverage area configurations.

Tag units 18a-b are configured to collect probe responses from transmitting points, such as standard wireless access points (AP) 16 and other tag units. When one of tag units 18a-b is configured to perform the functions of an call tag

18a, it may be provided to various persons for real-time tracking and locating in the event of an emergency. Tag unit 18a-b may be configured to be compatible with IEEE 802.11 wireless communication systems and designed for minimal bandwidth, enabling user 11 to utilize existing wireless local area network (WLAN) infrastructure 19. Tag units 18a-b may be capable of both high frequency (2.4 GHz) and low frequency (262 kHz) transmission. Tag units 18a-b may be managed through a mobile management resource management software. Units 18a-b can have dimensions of 1.9"×1.38"×0.7" with a weight of less than one ounce. Tag units 18a-b comprises a welded waterproof, chemical-proof case and may be mounted to an asset or a fixed reference location by adhesive, tie wrap, lanyard, or clip. Tag units 18a-b withstand temperatures from 0 to 120 degrees Fahrenheit and non-condensing humidity from 0 to 95%. Battery Life is typically 2-3 years (depending on how often it is polled). However, all tags do not necessarily have to come in the same physical form factor. Various tag units 18a-b may be different shapes, sizes and enclosures and they may be powered externally or battery powered. Tag units 18a-b may accept different battery types, or be rechargeable and have a docking station designed for battery recharging. Units 18a-b preferably have a range of 200-300 feet. Tag units 18a-b may receive FSK transmissions at 433.92 MHz, a WiFi signal or any other type of wireless signal (the interrogation signal) from mobile device 13a-b in the form of a poll.

In an exemplary embodiment, tag units 18a-b include a tamper detection security feature, tamper contacts, that prevents theft and loss of equipment by causing an alert when tag units 18a-b are removed from an asset or other fixed location (depending on the tag type). The contacts are connected to an adhesive pad that is used to attach tag units 18a-b to the asset or fixed location. When tag units 18a-b are removed from the asset or fixed location, the contacts in the adhesive pad break and come free from tag units 18a-b and a tamper is detected. U.S. Pat. No. 7,098,792 assigned to the assignee of the present application is herein incorporated in its entirety by reference and discloses tamper proof features.

Tag units 18a-b wake up periodically and look to receive the preamble of the interrogation signal from mobile device 13a-b. Each unit of units 18a-b that sees the poll in the area of mobile device 13a-b stays awake while watching for the Start Of Frame (SOF) and following data. The following data can include the department ID number for a group poll or the specific tag ID number for a tag specific poll. In a group poll (e.g., department poll), each of units 18a-b replies in its associated time slot based on the tag ID number of units 18a-b upon receiving the End Of Frame (EOF). Preferably, in a group poll (department) or tag specific poll, only units 18a-b from the selected group or the specifically selected units 18a-b respond. Tag units 18a-b are programmed to review the additional data for specific tag identification numbers or group identification numbers and respond only when those numbers match tag units 18a-b. If doing a tag specific poll, the tag being polled immediately replies upon seeing the EOF and valid checksum.

Although five tag units 18a-b are shown in FIG. 1, any number of tag units 18a-b can be utilized in system 10 without departing from the present application. In an exemplary embodiment, mobile device 13a-b provides an interrogation signal to units 18a-b, and units 18a-b respond to the interrogation signal by providing a tag identification to the mobile device 13a-b.

Units 18a-b can also respond to the interrogation signal with an indication of the received signal strength indication (RSSI). The indication is for the signal received by mobile



device **13b** from tag units **18a-b**. The RSSI can be displayed on mobile device **13b**. The RSSI provides a rough indication of the proximity of mobile device **13b** to the responding unit of tag units **18a-b**.

In an exemplary embodiment, call tag **18a** includes at least one call button that may be pressed by distressed person **11a** in the event of an emergency. When the call button is pressed an alert signal is communicated to positioning service **14** and the location of call tag **18a** is determined. The location of call tag **18a** and the alert signal are delivered to a database for reporting and analysis and published to end user applications. End user **11c** may use end user applications on client workstations **12**, laptops **15** and mobile devices **13a** to manage the response to the alert signal. For example, end user **11c** may provide the alert and call tag **18a** location to emergency responder **11b** and request that emergency responder **11b** locate and assist distressed person **11a**. Emergency responder **11b** may provide an acknowledgment signal to end user **11c** using mobile device **13b** so that end user **11c** is assured that the situation is being addressed.

Alternatively, the emergency response system may be configured to automatically notify emergency responder **11b** with the alert and location information from positioning service **14** without end user **11c** intervention. Emergency response locator system **10** may be further configured to automatically notify all qualified emergency responders **11b** within a predetermined proximity of distressed person **11a**. If no emergency responders are within the predetermined proximity, then the proximity from distressed person **11a** may be increased until an emergency responder **11b** is found.

With reference to FIG. 3C, in an exemplary embodiment, call tag **18a** may include multiple buttons for requesting different types of assistance corresponding to different types of emergencies. For example, one call button may be configured as personal crisis button **8a**, which would be used in situations where distressed person **11a** needs security assistance (e.g., notifying security that a car is being broken into in the parking garage). When this button is pressed the appropriate security and/or law enforcement personnel are provided with the alert and location of call tag **18a**. A second call button may be configured as medical crisis button **8b**, which would be used in situations where distressed person **11a** is in need of medical assistance (e.g., experiencing severe chest pains in parking garage, injured after a fall and unable to get up). Call tag **18a** may also include one or more LEDs **9** that blink to indicate to distressed person **11a** that the alert has been received and that help is on the way. Other types of display configurations may be provided on the call tag **18a**, such as an LCD display, an OLED display, LED display, electroluminescent displays (ELD), etc. A third call button may be configured as a panic button **8c**. Alternatively, a panic signal may be generated by holding buttons **8a** and/or **8b** for a predetermined period of time (e.g., hold down for 3 seconds). Panic button may be configured to notify all types of emergency responders.

Once an alert of panic signal is generated, call tag **18a** may be configured to enter into an alert mode (as described in U.S. Pat. No. 7,274,294 as SEEKER mode). In alert mode, call tag **18a** attempts to communicate with mobile device **13b** directly or through an ad hoc network configuration. Call tag **18a** may be configured to remain in alert mode until the alert or panic signal is deactivated by emergency responder **11b** using mobile device **13b**. The alert or panic signal may be deactivated automatically when mobile device **13b** is within a predetermined proximity (e.g. five feet) of call tag **18a**, or emergency responder **11b** may be required to deactivate the alert or panic signal via the user interface of mobile device **13b**. One

of the advantages of alert mode is that it allows call tag **18a** to communicate directly with mobile device **13b** when mobile device **13b** is within a certain range of call tag **18a**, even if there is no supporting wireless infrastructure (e.g., no reference tags **18b** or access points **16**). This is particularly helpful when there are holes in the wireless coverage area, or when the distressed person **11a** is moving (e.g., running). In addition to the call tag configuration described above, call tag **18a** may be a mobile device, such as a PDA or a mobile phone and loaded with firmware and software needed to perform the functions described above.

With respect to FIG. 4A, mobile device **13a-b** includes a display **54**, transceiver **56**, a user interface **58**, a memory **60** and a synchronization circuit **62**. Mobile device **13a-b** can be embodied as a dedicated unit fabricated from ASICs, hard-wired circuits, microprocessor-based control circuits configured by software, or other means for implementing at least one operation described below. Synchronization circuit **62** allows unit **13a-b** to communicate with another computer systems and to exchange data with other databases remote from unit **13a-b**.

Transceiver **56** can include an antennae **52**. Transceiver **56** preferably includes receiver circuitry and a microcontroller for decoding protocol to derive tag identification number, signal strength, and status of the tag.

Antennae **52** can be a whip antenna or a directional antenna. Antennae **52** allows a user to determine the direction and relative distance to RF tag units **18a-b** by pointing antenna **52** and monitoring the received signal strength from tag units **18a-b**.

The information decoded by the microcontroller on module **57** is provided to mobile device **13a-b** through the compact flash connector bus. Advantageously a driver is not required because the compact flash UART within module **57** communicates as a stream interface device. Data from module **57** is accessed as if it were a communication port.

Transceiver **56** may be configured to operate at 433 megahertz bands in a true ultra-low power radio protocol and utilize frequency shift keying (FSK). Transceiver **56** can achieve a bit rate of 9600 kilobit per second. Preferably, transceiver device is configured to communicate using IEEE 802.11 wireless communication standard, however, various other wireless communication standards, frequencies and modulation schemes may be used.

With reference to FIGS. 4B-C, mobile device **13a-b** executing locator software is shown as handheld computer **59** and is preferably a commercially available handheld computer **59** (PDA). Handheld computer **59** may be a pocket PC OS2003-based device and memory **60** preferably includes at least 512 megabytes of RAM. In addition, memory **60** can include or alternatively be flash memory, EEPROM, or any device for providing storage. Handheld computer **59** can be Axim® X 13, manufactured by Dell. Handheld computer **59** preferably includes an integrated transceiver **56** and antenna **52** configured for wireless communication. Alternatively, handheld computer **59** may include a plug-in RF module **57**. Plug-in RF module **57** can utilize a compact flash, low power transceiver.

Display **54**, a user interface **58**, memory **60** and synchronization circuit **62** are implemented by handheld computer **59**. Transceiver **56** may be integrated into handheld computer **59** or implemented by RF module **57**. The use of handheld computer **59** provides significant hardware cost savings, reduces training time because handheld computer **59** has an already recognized easy to use interface, and allows unit **13a-b** to be incorporated into equipment already carried by the user.

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User interface 58 is preferably a touch screen associated with computer 59 (a commercially available handheld computer). Display 54 is preferably a color LCD display associated with computer 59. Preferably, transceiver 56 is integrated into handheld computer 59. Alternatively, module 57 can slide into the compact flash Type 2 slot in computer 59. In another alternative, module 57 can be a non-plug-in device coupled to handheld computer 59 by a connector (e.g., USB, FireWire, RJ45, RCA, coaxial).

Referring to FIG. 5, a parking garage, including a wireless mesh configuration for tracking and locating call tag 18a, is illustrated. The wireless mesh network is created from multiple reference tags 18b and AP 16 positioned at various locations throughout the parking garage. In the mesh configuration, call tag 18a will transmit packets of collected information to reference tags 18b and AP 16, which may then deliver the collected packets to the network, such as LAN 17, and then to positioning service 14. The packets may be delivered to the network via a wired or wireless connection from a designated reference tag 18b or AP 16. In the event of an emergency situation in the parking garage, distressed person 11a uses call tag 18a to generate an alert signal. The alert signal may be generated by pressing a button on call tag 18a or by sensing an environmental condition. The alert signal is delivered over the wireless mesh network using reference tags 18b and AP 16 to positioning service 14. The location of the call tag 18a is determined and the end user 11c is provided with the alert signal and the location of the call tag 18a. Emergency responder 11b is notified via mobile device 13b of the alert and the location of call tag 18a. Emergency responder 11b and/or end user 11c may acknowledge that the alert has been received and help is on the way. The acknowledgement is relayed to call tag 18a, and, as mentioned above, call tag 18a may be configured to notify distressed person 11a that help is on the way (e.g., blinking LED).

Emergency responder 11b attempts to locate distressed person 11a by using mobile device 13b. Mobile device 13b communicates with positioning service 14, which is able to determine the location of mobile device 13b and call tag 18a using the RSSI or TOF values measured from the surrounding reference tags 18b in the wireless mesh configuration. Mobile device 13b may be configured to display a map of the coverage area, including markers representing mobile device 13b and call tag 18a. Reference tags 18b may also be displayed on the map. Preferably, the graphical representation of the markers for mobile device 13b, call tag 18a and reference tag 18b are different. As emergency responder 11b moves closer to call tag 18a, the markers on mobile device 13b are updated to show the current location of mobile device 13b and call tag 18a. In this way emergency responder 11b locates distressed person 11a. The mapping feature is further described in co-pending U.S. patent application Ser. No. 12/036,136 entitled "WIRELESS MESH NETWORK FOR AN ASSET TRACKING SYSTEM" and co-pending U.S. patent application Ser. No. 12/178,480 entitled "ASSET TRACKING SYSTEM" both of which are assigned to the assignee of the present application and incorporated herein by reference in their entireties.

Mobile device 13b may also be configured to operate in a normal finding mode to detect whether tag units 18a-b are in a particular coverage area, or in a tracking mode to find a tag unit 18a-b (whether or not the unit is in the particular coverage area). Tag units 18a-b may be configured to provide a periodic, locating beacon signal that can be received by mobile device 13b. The beacon signal can be utilized by mobile device 13b to determine a location of, or relative distance to, a call tag 18a when it has left a coverage area (e.g.,

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if distressed person 11a is located in a hole in the coverage area). The periodic beacon signal can be provided in response to an interrogation signal from mobile device 13b. Alternatively, the beacon signal can be automatically provided by tag units 18a-b for predetermined periods of time and/or at predetermined intervals. The length of the intervals may change depending on the mode of operation of the tag units 18a-b (e.g., shorter periods between transmissions when in alert mode).

Mobile device 13b may be configured to perform a continuous roll call of all tag units 18a-b within a range (e.g., settable and up to 1000 ft.) of mobile device 13b in the ranger mode. The roll call may further be restricted to call tags 18a or by regions within the coverage area. If a call tag 18a, from which an alert signal has been generated, leaves the coverage area of mobile device 13b, an alert can be issued from mobile device 13b indicating that a call tag 18a has left the area.

Emergency responder 11b can also configure mobile device 13b in a tracker mode to search for call tag 18a utilizing a directional antenna, such as the one describe in U.S. Pat. No. 7,365,645. When call tag 18a receives a tracking message (interrogation signal) from mobile device 13b, call unit 18a may be configured to respond with a beacon signal and enter into a fast poll mode to allow very fast poll responses, thereby allowing superior tracking. Call tag 18a and mobile device 13b may be configured to enter the fast poll mode for a predetermined period of time, after which, both mobile device 13b and call tag 18a go back to a normal poll sequence.

In both range mode and tracker mode, mobile device 13b attempts to communicate directly with call tag 18a and to determine a relative direction and distance from mobile device 13b using collected RSSI or TOF information. In this way, emergency responder 11b may quickly locate distressed person 11a in the parking garage even if distressed person 11a is moving or is located in a hole in the coverage area. Furthermore, historical and/or statistical information provided by positioning service 14 can assist mobile device 13b when in normal finding mode and tracking mode in determining the relative direction and distance from mobile device 13b. For example, if call tag 18a leaves a coverage area, positioning service may provide a last known location of call tag 18a, which may provide a general direction and minimum distance of call tag 18a from mobile device 13b. This additional information provided by positioning service 14 can help narrow the search area and improve the ability of mobile device 13b to locate call tag 18a using direct communication.

Normal finding mode and tracking mode are initiated and performed by mobile device 13b. As described above, call tag 18a may enter into alert mode when a panic signal is initiated. Alternatively, alert mode may be entered into when an alert signal is generated by call tag 18a. If distressed person 11a initiates alert mode in the parking garage, call tag 18a attempts to communicate directly with mobile device 13b when mobile device 13b is within range of call tag 18a, even if there is no supporting wireless infrastructure (e.g., no reference tags 18b or access points 16). As previously stated, direct communication between mobile device 13b and call tag 18a is particularly helpful when there are holes in the wireless coverage area, or when the distressed person is moving (e.g., running).

Referring to FIG. 6A, distressed person 11a located within the coverage area and sends an alert. Emergency responder 11b, also within the coverage area, uses mobile device 13b to connect to the wireless mesh network comprising AP(s) 16 and reference tags 18b. Positioning service 14 may be used to determine the location of call tag 18a and mobile device 13b and publish the location information on mobile device 13b.

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Conversely, call tag **18a** and/or mobile device **13b** may be configured to be self-locating devices using the known positions of the reference tags **18b** and AP(s) **16**. Mobile device **13b** user interface may use visual indicators, such as position markers on a map or signal strength bar graphs, assists emergency responder **11b** in locating distressed person **11a**.

FIG. 6B illustrates a situation where distressed person is located in a coverage area hole **30**, such that AP **16** and reference tag **18b** are unable to communicate with call tag **18a**. In this situation, when a distressed person **11a** initiates alert mode on call tag **18a**, call tag **18a** attempts to contact the wireless mesh network and/or mobile device **13b** by periodically transmitting a signal. Mobile device **13b** responds and determines a relative direction and distance using RSSI and/or TOF information. Alternatively, rather than enter normal finding mode, mobile device **13b** may enter tracking mode. In tracking mode, mobile device **13b** transmits an interrogation signal causing call tag **18a** to respond with a beacon signal and to enter into a fast poll mode. Mobile device **13b** rapidly and continuously polls call tag **18a** for a predetermined period of time to determine the relative direction and distance of call tag **18a**. A directional antenna, such as antenna **57C** describe in U.S. Pat. No. 7,365,645, may be utilized to improve the determination of the relative direction of call tag **18a**.

Referring to FIG. 7A, emergency response locator system **10** may also be utilized by organizations, such as hospitals, nursing homes or other types of care facilities to locate individuals needing immediate assistance. Reference tags **18b** are battery powered making it easy to expand the wireless coverage area by affixing reference tags **18b** at various locations in the care facility. The location of the various reference tags **18b** and AP(s) **16** throughout the facility and determined during installation, thereby providing reference points for determining the location of caller tags **18a** and mobile devices **13a-b** as the caller tags **18a** and mobile devices **13a-b** move throughout the facility. Distressed person **11a** carries call tag **18a**, which may be used to request assistance in the event of an emergency. When an emergency event arises, distressed person **11a** presses at least one button on call tag **18a**, which communicates an alert signal to positioning service **14**. Positioning service **14** determines the location of call tag **18a** and provides the alert and the call tag **18a** location to end user **11c** and emergency responder **11b**. Once the location of call tag **18a** is determined, call tag **18a** may be notified and may be configured to provide an indication, such as a blinking LED, to distressed person **11a** that help is on the way.

Referring to FIG. 7B, emergency responder **11b** uses mobile device **13b** to locate call tag **18a**. The care facility may provide secured areas for the safety of the residents or patients of the facility. The doors securing the secured areas of the facility may be configured with Wi-Fi or 262 kHz door receiver **22** as described in co-pending U.S. patent application Ser. No. 12/036,136 and co-pending U.S. patent application Ser. No. 12/178,480. As emergency responder **11b** approaches the secured area with mobile device **13b**, the doors controlled by receiver **22** automatically open to provide emergency responder **11b** access to the secured area in order to locate and assist distressed person **11a**. Distressed person **11a** may also initiate an alert or panic signal. Call tag **18a** may be configured to enter alert mode once an alert or panic signal is initiated. Call tag **18a** may be configured to remain in alert mode until the alert or panic signal is deactivated by emergency responder **11b** using mobile device **13b**. The alert or panic signal can be deactivated automatically when mobile device **13b** is within a predetermined proximity (e.g. five feet) of call tag **18a**, or emergency responder **11b** may be required

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to deactivate it via the user interface of mobile device **13b**. Alert mode allows mobile device **13b** to locate call tag **18a** even if there is no wireless coverage in the immediate area (e.g., 150 ft radius around call tag **18a**). In alert mode, call tag **18a** may be configured to attempt to communicate directly with mobile device **13b** to determine a relative direction and distance from mobile device **13b** to call tag **18a**.

Mobile device **13b** may also be configured to display a picture of distressed person **11a**, their name and the signal strength associated with the signal received from call tag **18a**. The picture of the distressed person **11b** and other persons in the facility may be stored in a central database and automatically loaded onto mobile device **13b** when the alert signal and location information is provided to mobile device **13b**. Alternatively, the pictures may be stored on mobile device **13b**. The signal strength can be displayed on a bar graph.

Mobile device **13b** may also enter tracking mode. In tracking mode, emergency responder **11b** may use a directional antenna with mobile device **13b** to determine the location of distressed person **11a**. When tracking, mobile device transmits an interrogation signal and call tag **18a** responds to the interrogation signal with an interrogation response beacon signal.

Referring to FIG. 8, a method for locating a call tag in a coverage area is shown. In step **800** reference tags **18b** receive a first signal from the call tag. Access points **16** may also receive the first signal. The first signal may be a probe request message signal that requests a response signal from the reference tags **18b**.

In step **802**, the reference tags **18b** send response signal to the call tag. Alternatively, as described above, reference tag **18b** can send a special message to tag units **18a-b** at a pre-configured time interval. Reference tags **18b** synchronize with each other in order to send their messages at approximately the same time. Call tag **18a** wakes to listen for messages from all reference tags **18b**. Under this scenario, call tag **18a** does not need to send a probe request message to reference tag **18b**. However, a probe request message may be needed when communicating with AP **16**.

After receiving signals from reference tags **18b**, in step **804**, call tag **18a** collects signal information from each of the response signals from the reference tags **18b**. The signal information may include RSSI information, TOF information or any other type of signal information useful in determining the location of call tag **18a**.

In step **806**, call tag **18a** generates a second signal including data based on the collected signal information of the response signals. In step **808**, the second signal is provided to a positioning service via a network (e.g., LAN). The second signal may be provided to positioning service **14** by transmitting the second signal from the call tag **18a** to a reference tag **18b** coupled to the network or to an access point coupled to the network.

In step **810**, the location of the call tag **18a** in the coverage area is determined based on the information provided in the second signal. The positioning service **14** may be configured to analyze the information, such as the RSSI and TOF information to determine the approximate distance of the call tag **18a** from each of the reference tags **18b**. In step **812**, the location of the call tag **18a** is provided to a portable electronic device, such as mobile device **13b**. The location of the call tag **18a** may be used by an emergency responder carrying mobile device **13b** to locate distressed person **11a** carrying call **18a** in the coverage area.

Referring to FIG. 9, a method for configuring or installing an emergency response locator system is illustrated. In step **900**, the reference tags **18b** are positioned in the coverage.

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The reference tags **18b** may be used to increase the coverage density of an existing wireless network to increase location determining accuracy, to expand the size of the coverage area, or both. In step **902**, at least one of the reference tags **18b** is coupled to a network, such as a local area network (LAN) or a wide area network (WAN), either directly as a client on the network or through a network device, such as an access point **16**. Step **902** may also be performed after steps **904**, **906** or **908**.

In step **904**, the location of each of the reference tags **18b** in the coverage area is determined at the positioning system, such as positioning service **14**. This may be accomplished by uploading or creating a floor plan of the coverage area in a software program and identifying the location of each of the reference tags **18b** and access points **16**. The location data may be entered using various data entry methods, including a drag and drop method where an icon representing the reference tag is selected and dragged to the spot on the floor plan where the reference tag is located. In step **906**, the location of the each of the reference tags in the coverage area is stored in memory coupled to the network. The memory may be integrated into positioning service **14** or provided in a server, workstation or other electronic devices coupled to the network. In addition to storing information related to the reference tags **18b**, propagation information for barriers in the coverage area that might affect the propagation of wireless signals may be provided. For example, a wall structure may attenuate signals passing through the wall resulting in a weaker signal than expected by the receiving device. This attenuation may be accounted for by providing the positioning system with the location and propagation information (e.g., attenuation factors) for the barriers in the coverage area.

It is understood that, while preferred embodiments, examples and values are given, they are for the purpose of illustration only. The apparatus and method of the invention are not limited to the precise details and conditions disclosed. For example, although specific geometries, ranges, and protocols and types of operations are described, other algorithms, dimensions, and protocols could be utilized. Thus, changes may be made to the details disclosed without departing from the spirit of the invention, which is defined by the following claims.

What is claimed is:

1. A system for use with a plurality of reference tags disposed at respective reference locations in a coverage area and configured to form a wireless mesh network, the system comprising:

a first tag configured to communicate with the plurality of reference tags wherein the first tag operates in a sleep mode and includes a motion sensor, wherein the first tag is woken out of the sleep mode on a first periodic basis to communicate with the reference tags, wherein the first tag is woken out of the sleep mode at a second periodic basis in response to a motion signal from the motion sensor, the second periodic basis being more frequent than the first periodic basis; and

a positioning system configured to receive data related to a communication between the first tag and the plurality of the reference tags, the positioning system being configured to process the data to determine a location of the first tag.

2. The system of claim 1, wherein the first tag is an asset tag.

3. The system of claim 1, wherein the data is related to signal strength.

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4. The system of claim 1, further comprising:  
an access point configured to couple the positioning system to the wireless mesh network.

5. The system of claim 1, wherein the first tag provides a periodic transmission of a first signal, wherein a portable electronic device is configured to directly receive the first signal when the portable electronic device is within range of the first tag.

6. The system of claim 5, wherein the periodic transmission of the first signal is configured to stop when the portable electronic device is within a predetermined range of the first tag.

7. The system of claim 5, wherein the periodic transmission of the first signal is configured to continue until deactivated by the portable electronic device.

8. The system of claim 1, wherein a portable electronic device is configured to directly communicate with a call tag when the portable electronic device is within range of the first tag.

9. The system of claim 8, wherein the positioning system is configured to provide the portable electronic device with a last known location of the first tag if the first tag can no longer be identified by the positioning system.

10. In a system for use with a plurality of reference tags disposed at reference locations in a coverage area and configured to form a wireless mesh network, a tag unit comprising:

a processor configured to communicate with the plurality of reference tags and to collect data regarding communication with the plurality of reference tags; and

a motion sensor, wherein the tag unit operates in a sleep mode, wherein the tag unit is woken out of the sleep mode on a first periodic basis to communicate with the reference tags, wherein the tag unit is woken out of the sleep mode at a second periodic basis in response to a motion signal from the motion sensor, the second periodic basis being more frequent than the first periodic basis.

11. The tag unit of claim 10, further comprising:

a portable electronic device configured to communicate with the wireless mesh network and the tag unit and to receive positioning information for locating the tag unit in the coverage area.

12. The tag unit of claim 10, wherein the plurality of reference tags and the tag unit are configured to communicate using an IEEE 802.11 standard.

13. The tag unit of claim 10, wherein the plurality of reference tags are coupled to a local area network (LAN).

14. The tag unit of claim 13, wherein the local area network is a wireless local area network (WLAN).

15. The tag unit of claim 13, wherein a first signal is sent to a remote emergency responder, wherein the first signal includes location information of the tag unit in the coverage area.

16. A method of determining a location of a tag unit in a wireless emergency response network, the method comprising:

waking the tag unit from a sleep mode on a first periodic basis to communicate with a plurality of reference tags disposed in a coverage area;

waking the tag unit from the sleep mode at a second periodic basis in response to a motion signal from a motion sensor, the second periodic basis being more frequent than the first periodic basis; and

determining the location of the tag unit in the coverage area based on data associated with communication between the tag unit and the reference tags.

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**17.** The method of claim **16**, further comprising:  
determining the location of the tag unit in the coverage area  
based on signal strengths of the communication.

**18.** The method of claim **16**, further comprises:  
providing the location of the tag unit in the coverage area to 5  
a portable electronic device, wherein the portable elec-  
tronic device is configured to communicate with the  
reference tags.

**19.** The method of claim **18**, wherein the portable elec-  
tronic device is configured to communicate directly with the 10  
tag unit when the tag unit is within range of the portable  
electronic device.

**20.** The method of claim **19**, wherein the plurality of ref-  
erence tags are coupled to the network via an access point.

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